



## Quantifying independent risk factors for failing to rescreen in a breast cancer screening program in Flanders, Belgium

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### ABSTRACT

**Background.** Mammographic screening may reduce breast cancer mortality by about 20%, provided participation is high and women screen regularly. We quantified independent risk factors for failing to rescreen and built a model to predict how rescreening rates change if these risk factors would be modified.

**Methods.** Multivariate analysis was used to analyze data from a prospective study which included a self-administered questionnaire and rescreening status 30 months after a t0 mammogram, using a random sample of women 50–67 years (Belgium 2010–2013).

**Results.** A false positive result at the most recent past mammogram (Odds Ratio = 5.0, 95% Confidence Interval 3.6–6.8), an interval until new invitation greater than 25 months (Odds Ratio = 4.8 for >29 months, 95% Confidence Interval 2.9–8.1), waiting times in the mammography unit > 1 h (Odds Ratio = 2.1, 95% Confidence Interval 1.2–3.7) and difficulties in reaching the unit (Odds Ratio = 2.5, 95% Confidence Interval 1.4–4.4) were the strongest independent predictors for failing to rescreen. The area under the curve of the receiver operating characteristic analysis was 0.705 for the model development stage and 0.717 for the validation stage and goodness-of-fit was good.

**Conclusions.** Maintaining an invitation cycle of maximum 25 months, limiting waiting time in the mammography unit and lowering the number of false positives could increase breast cancer screening compliance.

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### Background

The Belgian incidence rate of breast cancer is 178.2/100,000 person years (106.0/100,000 World Standard Population). In Belgium and many other Western style countries breast cancer is the leading cause of cancer death in females, contributing to a large interest in the possibilities for prevention. Mammographic screening has both harmful effects (e.g. overdiagnosis) and benefits (e.g. breast cancer mortality reduction). These have been under intense scrutiny for more than a decade and this debate is unlikely to end soon. Recently a review panel

found that breast cancer specific mortality can be reduced by about 20% in women over 50 years old who were invited to screening but the levels of participation and rescreening rates are important limitations in accomplishing this (Blanchard et al., 2004; Marmot et al., 2013; Michaelson et al., 2002; Tabar et al., 2011).

European guidelines suggest evaluating rescreening behavior by calculating the percentage of women that rescreen within 30 months of their last mammogram (Perry et al., 2008). Literature describes several risk factors for not rescreening: low education (Sheppard et al., 2008), low household income (Intermutualistisch Agentschap, 2010), infrequent contact with a physician (François et al., 2012; Somkin et al., 2004; Tang et al., 2009), little ability to take time off work (Liu and Clark, 2008; Peipins et al., 2006), higher age (Somkin et al., 2004), no personal or familial history of breast problems (Blanchard et al., 2004; Marshall, 1994), the absence of a formal reminder system and the presence of financial barriers.

The purpose of this study is to examine and quantify variables which are independently related to rescreening in the Flemish Breast Cancer Screening Program (BCSP) and build a valid prediction model to predict

**Abbreviations:** BCSP, breast cancer screening program; AUC, area under the curve; ROC, receiver operating characteristic.

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how rescreening rates would change if these risk factors would be influenced.

## Methods

### Screening in Belgium

Cancer prevention in Belgium is organized by the three regions. The Flemish region has 6.2 million of Belgium's 10.8 million inhabitants and started a BCSP in compliance with European guidelines in June 2001. In the BCSP all eligible women in the age group 50–69 receive a personalized letter every two years with a set appointment for a screening mammogram which is paid directly and entirely by healthcare insurance to the mammography unit. The date, time and place of the appointment can easily be changed by phoning a toll free number which results in about 1/3 of all BCSP mammograms being taken on a rescheduled appointment. Women with symptoms or an elevated risk of breast cancer are encouraged to consult a physician rather than participating in the BCSP.

Before June 2001 breast cancer screening was only possible as opportunistic screening, which is by prescription only. Opportunistic screening, unlike the BCSP, does not include organized quality control (e.g. double reading) and its data are not stored in one central database. The doctor's fee for opportunistic screening is higher than for BCSP screening, it includes a higher insurance contribution and a higher patient contribution (between 15 and 30 euro compared to 0 euro in the BCSP), resulting in a higher cost for the woman and the healthcare system.

The percentage of women screened in the periods 1999–2000, 2001–2002 and 2006–2007 was 33%, 27% and 21% in opportunistic screening and 0%, 23% and 44% through the BCSP (adding percentages provides total coverage) (Intermutualistisch Agentschap, 2010). Data on the usage of clinical breast exams or self-exam in Belgium are not available but national GP guidelines do not recommend clinical breast exams or self-exam for screening of asymptomatic average risk women, although women are encouraged to develop breast awareness.

### Study population

At the time of screening all women are asked to consider giving written informed consent to allow the use of their screening data for scientific research (given by 99.5%). Only women that signed informed consent were candidates for the study. Women were eligible for inclusion in the study if in 2010 they lived in the provinces of Antwerpen or Vlaams-Brabant and had a BCSP mammogram done in 2010 ( $n = 61,221$ ), a random sample of them was included in the study ( $n = 21,167$ ). Inclusion meant they received a satisfaction questionnaire (see below) together with the invitation for screening. 1487 women of the random sample (7.0%) were no longer eligible to participate in the BCSP two years after their t0 mammogram (moved out of Flanders, breast cancer diagnosis, died or aged outside the BCSP age-limits). Their answers were needed for representative feedback on client satisfaction for the mammographic units but left out of the analysis. Of the remaining 19,680 women, 6965 returned the questionnaire (response rate 35.4%).

### Questionnaire

The search for a validated satisfaction questionnaire included publications from the last 20 years, supplemented with references that were mentioned in the retrieved articles. No validated satisfaction questionnaire was available in Dutch so we constructed one based on three validated English language questionnaires (Almog et al., 2008; Loeken et al., 1996; Tang et al., 2009), which were selected because they were culturally appropriate to the Flemish situation. One researcher translated the selected questions into Dutch, after which another researcher performed back translation. To examine the applicability of this preliminary survey it was administered to a group of 9 hospital volunteers who had undergone mammogram in the last year. Several modifications were then made to avoid confusion.

The questions of the final questionnaire can be seen in Table 2. The variable *Result of screening of t0 mammogram* had two possible values: false positive recall versus no recall for further assessment (recall rate is the number of women recalled for further assessment as a proportion of all women who had a screening examination). Women with true positive recall were diagnosed with breast cancer and therefore not included in the study. Waiting time for results is defined as the days between screening date and the date that the result letter is

sent. Waiting time in the mammography unit is the time spent in the waiting room of the unit. All satisfaction questions used a 5-point Likert scale except for the question on difficulties in reaching the unit (e.g. great distance or transport problems) which used a yes/no option as in the study where it was originally developed. The other independent variables in Table 2 are part of the BCSP database.

### Database construction

In July 2013 the BCSP database was linked to the returned questionnaires with the use of a unique identifier which was then removed from the study database. The 2010 mammogram is referred to as the t0 mammogram while a mammogram by the same woman in 2012 or 2013 is referred to as the t1 mammogram. Every woman had 913 days of follow up after her t0 mammogram, at which point rescreening status was determined for each woman. A t1 mammogram taken more than 913 days after the t0 mammogram was not counted towards rescreening status at 30 months.

### Analysis

To evaluate non-response bias we compared characteristics of responders and either non-responders or the women of the sample area depending on whether the variable is available for the non-responders.

The answers to the questionnaire, together with a selection of variables from the BCSP database, were used as independent variables in the multivariate analysis that used rescreening status after 30 months as dependent variable.

Analysis and data storage were done using STATA version 10 (StataCorp., USA). Relationships between two categorical variables were examined with contingency tables using Chi square test and crude OR's with 95% CI. Univariable relationships between continuous variables and outcome were assessed using logistic regression. Variables were all categorized, with grouping of values based on clinical similarity (e.g. age) or similarity of crude OR (e.g. month of invitation, waiting time for result letter). Resulting categories can be found in Table 2, with crude OR and 95% CI.

A multiple logistic regression model to predict individual status of rescreening after 30 months was built on a random sample of 2/3 of the data; the remaining 1/3 was used to validate the model. The variables age, education and screening round were always included irrespective of statistical significance since these variables have previously been shown to be clinically important variables to adjust for. Other variables were only candidates for purposeful selection if they had p-values <0.25 in univariable analysis. Whether or not a variable was added to the model was based on the likelihood ratio test with significance set at  $p < 0.01$ .

The assessment of the resulting model was done by assessing the goodness of fit using the Hosmer–Lemeshow goodness-of-fit statistic and examining the discriminatory accuracy using the area under the curve (AUC) of the receiver operating characteristic (ROC) analysis.

### Prediction

The regression coefficients of the variables in the final model were rounded to 4 decimals and used to create the  $\beta$  of formula 1, which calculates the predicted individual probability ( $p_i$ ) for each patient to rescreen. The rescreening rate in the population was calculated as the arithmetic mean of these individual probabilities. Formula 1 was used to predict the rescreening rate in a situation where the  $X_i$  has been influenced (see example in Results, Model prediction).

#### Formula 1. Type of model to predict rescreening status at 30 months after t0 mammogram

$$\logit(p_i) = \ln(p_i / 1 - p_i) = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \dots + \beta_m X_{m,i}$$

$p_i$ : predicted probability of rescreening

$\beta$ : coefficient from the model

$X$ : risk factor value

## Results

Table 1 compares responders and non-responders or the women of the sample area, depending on whether the variable was available for the non-responders. We found no differences in age, employment

**Table 1**  
Distribution of demographic and other characteristics among responders and non-responders<sup>a</sup>. Flanders, Belgium 2010–2013.

	Responders <sup>a</sup>		Non-responders <sup>b</sup>		Sample area 2010 <sup>c</sup>		p-Value
All, % (N)	100.0	(6965)	100.0	(12,715)	100.0	(270,596)	
Age at t0 mx, mean age in years (SD)	58.0	(5.1)	58.0	(5.1)			0.43
Education of 50–64 year olds (ISCED classification), % (N)							<0.01
• Low-level	37.0	(2162)			38.4	(103,825)	
• Mid-level	33.3	(1950)			34.7	(93,862)	
• High-level	29.7	(1737)			26.9	(72,909)	
• Missing	–	(189)			–	(0)	
Employment of 50–64 year olds, % (N)							0.72
• Full time or part time employment	46.9	(2780)			46.7	(126,236)	
• Not employed	53.1	(3149)			53.3	(144,360)	
• Missing	–	(109)			–	(0)	
Rescreening status 30 months after t0 mx, % (N)							<0.01
• Rescreened	84.4	(5876)	81.8	(10,399)			
• Not rescreened	15.6	(1089)	18.2	(2316)			
Recalled for further assessment after t0 mx, % (N)							0.81
• No	96.0	(6685)	96.1	(12,212)			
• Yes	4.0	(280)	3.9	(502)			

<sup>a</sup> Responders 50–67 years old at the time of t0 mx for all variables except for education and work status (50–64 years old).

<sup>b</sup> Non-responder 50–67 years old at the time of t0 mx.

<sup>c</sup> Women in the sample area 50–64 years old.

status and recall rate for further assessment. Responders have a slightly higher adherence to rescreening at 30 months (84.4% versus 81.8%,  $p < 0.01$ ) and women with a high level of education were more likely to respond ( $p < 0.01$ ).

#### Descriptive analysis

The results of the descriptive analysis are shown in Table 2 and are not further commented on here. The overall rescreening rate within 30 months was 84.4%, meaning 15.6% of eligible screened women who were in the study did not return for screening.

#### Association analysis

In the model building stage 4602 records were used (a random 2/3 sample of all 6965 available records), the remaining 2365 were used for model validation. Despite a sometimes strong crude OR the following variables were not included in the model due to statistically insignificant multivariate results: employment status, experienced roughness, whether the women felt free to ask anything, treatment by receptionist and technician, and the type of physician who discussed the t0 results with the woman (see Table 2).

The strongest independent associations were observed for a false positive result of the t0 mammogram (OR = 5.0, 95% CI 3.6–6.8) and an interval until new invitation that surpasses 25 months (OR = 4.8 for >29 months, 95% CI 2.9–8.1). Of the satisfaction variables the strongest associations are waiting times in the mammography unit (OR = 2.1 for >60 min, 95% CI 1.2–3.7) and difficulties in reaching the unit (mainly great distance and transportation inconveniences such as few parking spots and difficult public transport) (OR = 2.5, 95% CI 1.4–4.4).

Pain and embarrassment are overall significantly associated (likelihood ratio test) and therefore included but not every sublevel achieves significance due to small numbers in some categories. The oldest age group has an OR of 2.4 (95% CI 1.8–3.2) for not rescreening.

#### Model assessment

The AUC of the ROC analysis was 0.705 for the model development stage (2/3 of the data) and 0.717 for the validation stage (1/3 of the data). The goodness-of-fit of the model, tested on both development and validation data, was good with non-significant Hosmer–Lemeshow statistic (0.947 and 0.154).

#### Model prediction

Table 3 shows the predicted rescreening rate ( $p_i$ ) according to the model (see also formula 1) for different situations, first the current distribution of the variable is used, then the  $p_i$  is calculated for the situation where all the women are in the reference category for that variable (while all other variables stay the same). An example is the situation where reaching the unit is no longer a problem for any of the women: the rescreening rates rise from 84.4% to 84.5%, a gain of 0.1%. The largest gain (1.8%) is seen for maintaining an interval of invitation of  $\leq 25$  months. If all of the mentioned variables could be positively influenced (waiting time, reachability, embarrassment, pain, recall rate, interval between invitation and the type of mammographic unit) the rescreening rate is predicted to rise from 84.4% to 91.1%.

#### Discussion

##### Risk factor OR

Strong risk factors for non-adherence to rescreening are a false positive result of the most recent past mammogram (OR = 5.0, 95% CI 3.6–6.8) and waiting times of more than 1 h in the unit (OR = 2.1, 95% CI 1.2–3.7). This is in line with previous research (Marshall, 1998; Álamo-Junquera et al., 2012; Baines et al., 1990). The level of education is not significantly associated with rescreening which contradicts previous research that shows that low education is correlated with lower rescreening rates (Sheppard et al., 2008). Since women with a higher education are more likely to switch to opportunistic screening (Intermutualistisch Agentschap, 2010) and the data of opportunistic screenings are not registered in the BCSP database the two phenomena have probably canceled each other out. Women in the oldest age group are more than twice as likely not to rescreen, this is in line with previous research (Intermutualistisch Agentschap, 2010; Somkin et al., 2004).

The model (see also formula 1) is used to predict the rescreening rate ( $p_i$ ) for situations where modifiable risk factors are dealt with (see Table 3). This shows that influencing risk factors with large OR does not necessarily yield a large gain in rescreening rates. The influence of reducing the number of women that receive a false positive recall after t0 mx (1.1% increase) is much lower than the size of the OR (5.0) would lead one to expect, this is due to the fact that false positive recall is relatively uncommon (4.0%), the % increase will be larger in settings with higher false positive recall. Lowering false-positives is a trade off with the increase of interval cancers (a primary breast cancer diagnosed

**Table 2**

Risk factors for non-adherence to rescreening within 30 months of t0 mammogram in a BCSP, Flanders, Belgium 2010–2013.

		Study participants		Study participants rescreened within 30 months		Crude OR for not rescreening (95% CI)		Adjusted OR for not rescreening (95% CI)	
		N	(%)	N	(%)				
All study participants		6965	(100.00)	5876	(84.36)				
Questionnaire: t0 women's demographics	Age at t0 in years								
	50–54	2093	(30.05)	1715	(81.94)	Ref.		Ref.	
	55–59	2000	(28.72)	1716	(85.80)	0.75	(0.63–0.88)	1.47	(1.15–1.87)
	60–64	1945	(27.93)	1663	(85.50)	0.77	(0.65–0.91)	1.85	(1.43–2.40)
	65–69	927	(13.31)	782	(84.36)	0.84	(0.68–1.04)	2.38	(1.75–3.24)
	Education according to ISCED								
	Low-level	2633	(37.80)	2267	(86.10)	Ref.		Ref.	
	Mid-level	2186	(31.39)	1841	(84.22)	1.16	(0.99–1.36)	1.03	(0.84–1.27)
	High-level	1915	(27.49)	1580	(82.51)	1.31	(1.12–1.54)	1.28	(1.04–1.58)
	Missing	231	(3.32)	188	(81.39)	1.42	(1.00–2.01)	1.09	(0.64–1.86)
	Employment								
	Not working	4010	(58.48)	3436	(85.69)	Ref.		Ref.	
	Working part-time	1627	(23.35)	1372	(84.33)	1.11	(0.95–1.31)	–	
	Working full time	1190	(16.32)	959	(80.59)	1.44	(1.22–1.71)	–	
	Missing	138	(1.86)	109	(78.99)	1.59	(1.05–2.42)	–	
Questionnaire: women's experience in the mammographic unit during t0 mammogram	Did you have any difficulty in reaching the mammography unit?								
	No	6796	(97.86)	5750	(84.61)	Ref.		Ref.	
	Yes (great distance, transport inconvenience, other)	95	(1.17)	69	(72.63)	2.07	(1.31–3.27)	2.50	(1.42–4.40)
	Missing	74	(0.97)	57	(77.03)	1.64	(0.95–2.83)	1.53	(0.75–3.11)
	How long did you have to wait in the mammography unit?								
	≤20 min	5569	(79.96)	4771	(85.67)	Ref.		Ref.	
	>20 ≤ 60 min	1250	(17.95)	1000	(80.00)	1.49	(1.27–1.75)	1.31	(1.06–1.61)
	>60 min	94	(1.35)	64	(68.09)	2.80	(1.80–4.35)	2.14	(1.23–3.72)
	Missing	52	(0.75)	41	(78.85)	1.60	(0.82–3.13)	0.98	(0.35–2.73)
	Did you find the mammogram painful?								
	Strongly disagree–disagree	2574	(36.96)	2213	(85.98)	Ref.		Ref.	
	Neutral	2079	(29.85)	1765	(84.90)	1.09	(1.23–1.73)	1.11	(0.90–1.37)
	Strongly agree–agree	2275	(32.66)	1872	(82.29)	1.32	(1.23–2.12)	1.26	(1.03–1.55)
	Missing	37	(0.53)	26	(70.27)	2.59	(0.88–1.57)	1.75	(0.57–5.35)
	The examination made me feel embarrassed								
	Strongly disagree–disagree	5549	(80.77)	4746	(85.53)	Ref.		Ref.	
	Neutral	1001	(13.67)	803	(80.22)	1.46	(1.23–1.73)	1.26	(1.00–1.58)
	Strongly agree–agree	331	(4.42)	260	(78.55)	1.61	(1.23–2.12)	1.36	(0.94–1.96)
	Missing	84	(1.14)	67	(79.76)	1.50	(0.88–2.57)	1.08	(0.48–2.44)
	The examiner was too rough with me								
	Strongly disagree–disagree	5703	(81.88)	4865	(85.31)	Ref.		Ref.	
	Neutral	1106	(15.88)	901	(81.46)	1.32	(1.12–1.56)	–	
	Strongly agree–agree	130	(1.87)	92	(70.77)	2.40	(1.63–3.52)	–	
	Missing	26	(0.37)	18	(69.23)	2.58	(1.12–5.95)	–	
	I felt free to ask about anything								
	Strongly agree–agree	4975	(71.43)	4242	(85.27)	Ref.		Ref.	
	Neutral	1403	(20.14)	1164	(82.97)	1.19	(1.01–1.39)	–	
	Disagree–strongly disagree	432	(6.20)	344	(79.63)	1.48	(1.16–1.90)	–	

(continued on next page)

Table 2 (continued)

		Study participants		Study participants rescreened within 30 months		Crude OR for not rescreening (95% CI)		Adjusted OR for not rescreening (95% CI)	
		N	(%)	N	(%)				
All study participants		6965	(100.00)	5876	(84.36)				
Screening database: invitation t1	Missing	155	(2.23)	126	(81.29)	1.33	(0.88–2.01)	–	
	I was satisfied with the way the receptionist treated me								
	Strongly agree–agree	6307	(90.55)	5345	(84.75)	Ref.		Ref.	
	Neutral	549	(7.88)	445	(81.06)	1.30	(1.04–1.62)	–	
	Disagree–strongly disagree	82	(1.18)	67	(81.71)	1.24	(0.71–2.19)	–	
	Missing	27	(0.39)	19	(70.37)	2.34	(1.02–5.36)	–	
	I was satisfied with the way the technologist treated me								
	Strongly agree–agree	6457	(92.71)	5491	(85.04)	Ref.		Ref.	
	Neutral	419	(6.02)	316	(75.42)	1.85	(1.47–2.34)	–	
	Disagree–strongly disagree	63	(0.90)	48	(76.19)	1.78	(0.99–3.18)	–	
	Missing	26	(0.37)	21	(80.77)	1.35	(0.51–3.60)	–	
	Interval between t0 mx and t1 invitation								
	≤25 months	2292	(32.91)	1943	(84.77)	Ref.		Ref.	
	>25 ≤ 26 months	2640	(37.90)	2292	(86.82)	0.85	(0.72–0.99)	1.09	(0.89–1.34)
	>26 ≤ 27 months	975	(14.00)	802	(82.26)	1.20	(0.98–1.47)	1.42	(1.09–1.85)
	>27 ≤ 28 months	527	(7.57)	454	(86.15)	0.90	(0.68–1.18)	1.15	(0.80–1.64)
	>28 ≤ 29 months	321	(4.61)	245	(76.32)	1.73	(1.30–2.29)	2.05	(1.42–2.95)
	>29 ≤ 30 months	125	(1.79)	83	(66.40)	2.82	(1.91–4.15)	4.80	(2.86–8.07)
	>30 months	43	(0.62)	17	(39.53)	8.51	(4.57–15.90)	9.37	(4.50–19.51)
	Missing <sup>a</sup>	42	(0.60)	40	(95.24)	0.28	(0.07–1.16)	0.19	(0.03–1.47)
Screening database: characteristics screening participation t0	The woman's screening round at the time of t0 mammogram								
	1st	1581	(22.70)	1194	(75.52)	Ref.		Ref.	
	2nd	1431	(20.55)	1172	(81.90)	0.68	(0.57–0.81)	0.68	(0.54–0.86)
	3rd	1554	(22.31)	1345	(86.55)	0.48	(0.40–0.58)	0.40	(0.31–0.53)
	4th	1274	(18.29)	1125	(88.30)	0.41	(0.33–0.50)	0.35	(0.26–0.47)
	5th	1125	(16.15)	1040	(92.44)	0.25	(0.20–0.32)	0.17	(0.12–0.24)
	Type of mammography unit at which t0 mammogram is made								
	Hospital based	3925	(56.35)	3382	(86.17)	Ref.		Ref.	
	Private radiologist	3040	(43.65)	2494	(82.04)	1.36	(1.20–1.55)	1.41	(1.17–1.68)
	Type of physician discussing result of t0 mammogram								
	GP	6235	(90.06)	5292	(84.88)	Ref.		Ref.	
	Specialist	730	(9.94)	584	(80.00)	1.40	(1.16–1.70)	–	
	Waiting time for result letter of the t0 mammogram								
	Up to 2w	3436	(49.33)	2846	(82.83)	Ref.		Ref.	
	Up to 4w	3311	(47.54)	2837	(85.68)	0.81	(0.71–0.92)	0.80	(0.67–0.95)
	Up to 6w	189	(2.71)	169	(89.42)	0.57	(0.36–0.92)	0.54	(0.29–1.01)
	More than 6w	29	(0.42)	24	(82.76)	1.00	(0.38–2.64)	0.92	(0.27–3.16)
	Result of screening of t0 mammogram								
	No recall for further assessment	6685	(95.98)	5719	(85.55)	Ref.		Ref.	
	False positive recall	280	(4.02)	157	(56.07)	4.64	(3.63–5.93)	4.95	(3.58–6.84)

“–”: the risk factor is not withheld in the final model (see [Methods](#)).

<sup>a</sup> 42 women who participated in the BCSP with a physician's prescription had not yet been given an appointment by letter.



**Table 3**Predicted<sup>a</sup> rescreening rates 30 months after t0 mammogram in a BCSP, Flanders, Belgium 2010–2013.

	$p_i$ (%)	Difference in $p_i$ (%) between current situation & ideal situation
Reaching the unit at t0		
• Current situation: 97.86% experience no difficulties	84.4	
• Ideal situation: 100% experience no difficulties	84.5	0.1
Waiting time in mammography unit at t0		
• Current situation: 79.96% wait $\leq 20$ min	84.4	
• Ideal situation: 100% wait $\leq 20$ min	85.3	0.9
Embarrassment during examination at t0		
• Current situation: 80.77% are not embarrassed	84.4	
• Ideal situation: 100% are not embarrassed	85.2	0.8
Pain during examination at t0		
• Current situation: 36.96% experience no pain	84.4	
• Ideal situation: 100% experience no pain	85.3	0.9
Recall for further assessment at t0		
• Current situation: 4.02% get false positive recall	84.4	
• Ideal situation: 0% false positive recall	85.5	1.1
Interval between invitations		
• Current situation: 32.91% $\leq 25$ months after t0 mx	84.4	
• Ideal situation: 100% are invited $\leq 25$ months after t0 mx	86.2	1.8
Type of mammographic unit at t0		
• Current situation: 56.35% are hospital based	84.4	
• Ideal situation: 100% are hospital based	86.1	1.7
All of the above		
• Current situation: all of the abovementioned situations	84.4	
• Ideal situation: all of the abovementioned situations	91.1	6.7

 $p_i$ : predicted rescreening rate.<sup>a</sup> Formula 1 describes the model.

in a woman in the interval between her last negative screening and her next invitation to screening) and should therefore be done using intensive feedback to radiologists about the outcome of the mammograms to minimize the chances of increasing the number of interval cancers. Women who are invited after 25 months are less likely to take up the invitation, possibly because they have entered into opportunistic screening by then. Mammography units that are privately owned have a markedly lower rescreening percentage, raising the question whether these women are more likely to switch to opportunistic screening.

### Strengths and weaknesses

Selection bias due to non-response is a possibility in our study because the questionnaire had an incomplete response. We attempted to evaluate whether our respondents are representative of the sample (detect selective non-response) by comparing the distribution of several characteristics between responders and non-responders.

We found no differences for age, recall for further assessment and work status while there were differences in adherence to screening and education. However, given the size of our study a difference can reach statistical significance without being clinically relevant. We conclude that selection bias is probably present but likely to be limited, meaning the descriptive results are biased to a certain extent while there may also be some overestimated or underestimated OR.

Measurement bias on data from the BCSP database is considered to be extremely low thanks to an important number of automated inconsistency checks that are performed when the data are entered. We attempted to limit measurement bias for the questionnaire data by basing our Dutch questionnaire on several English language questionnaires and by using front and back translation in combination with a small qualitative analysis of the resulting questionnaire. It cannot be excluded that the translation caused a change in validity of the questions, but the fact that the answers have a similar distribution in similar research is an indication that measurement bias of the questionnaire is limited. The ASE model was originally considered for the construction of the survey but it was finally not used. Some of the reasons for this were that we focused on the experience in the mammographic unit, and that social support variables are very difficult to modify (we were looking to find

ways to improve rescreening rates). Instead, a selection was made of those variables that are modifiable by small adaptations in the screening process, or important risk factors based on an extensive literature search. Our final model has a good AUC and goodness-of-fit making prediction possible (Hosmer and Lemeshow, 2000). Model assessment also shows that there must be additional variables that influence adherence which we did not include in the model. Such factors could include: discouraging physician recommendations (Baines et al., 1990; Maxwell et al., 2001), dissatisfaction with the method used to communicate results (Dolan et al., 2001), inability to get a mammogram appointment at a convenient hour and a woman's cancer knowledge (Liu and Clark, 2008; Maxwell et al., 2001; Peipins et al., 2006).

### Conclusions

We quantified significant risk factors for non-adherence to breast cancer rescreening and constructed a valid prediction model that has good fit although it was also shown that there are variables that play a role in rescreening behavior that were not included in our study. Rescreening rates can be increased by keeping the invitation interval close to 24 months, reducing the occurrence of false positive results in the previous round and maintaining waiting times in units  $< 20$  min. Such measures will increase the rescreening rates and thereby optimize the benefits of mammographic screening while they also reduce disadvantages of screening such as unnecessary biopsy, anxiety and discomfort.

### Conflict of interest statement

The authors declare that there are no conflicts of interests.

### References

- Álamo-Junquera, D., Murta-Nascimento, C., Macià, F., et al., 2012. Effect of false-positive results on reattendance at breast cancer screening programmes in Spain. *Eur J Public Health* 22 (3), 408–412.
- Almog, R., Hagoel, L., Tamir, A., Barnett, O., Rennert, Gad, 2008. Quality control in a national program for the early detection of breast cancer. *Women Health Iss* 18, 110–117.
- Baines, C.J., To, T., Wall, C., 1990. Women's attitudes to screening after participation in the national breast screening study. *Cancer*. 65, 1663–1669.

- Blanchard, K., Colbert, J., Puri, D., et al., 2004. Mammographic screening: patterns of use and estimated impact on breast carcinoma survival. *Cancer* 101, 495–507.
- Dolan, N., Feinglass, J., Priyaneth, A., Haviley, C., Sorensen, A., Venta, L., 2001. Measuring satisfaction with mammography result reporting. *J Gen Intern Med* 16, 157–162.
- François, G., Van Roosbroeck, S., Hoeck, S., Markovskaia, E., Van Hal, G., 2012. A pivotal role for the general practitioner in a mixed mammographic screening model. *Rev Epidemiol Sante* 60, 150–156.
- Hosmer, David W., Lemeshow, Stanley, 2000. *Applied Logistic Regression*, Second edition. John Wiley and sons, New York.
- Intermutualistisch Agentschap, 2010. Programma Borstkankerscreening Verslag nr. 7. Brussel, (Brussel).
- Liu, S., Clark, M., 2008. Breast and cervical cancer screening practices among disabled women aged 40–75: does quality of the experience matter? *J Womens Health* 17, 1321–1329.
- Loeken, K., Steine, S., Sandvik, L., Laerum, E., Finset, A., 1996. A new measure of patient satisfaction with mammography. Validation by factor analytic technique. *Fam Pract* 13, 67–74.
- Marmot, M., Altman, D., Cameron, D., Dewar, J., Thompson, S., Wilcox, M., 2013. The benefits and harms of breast cancer screening: an independent review. *Br J Cancer* 108, 2205–2240.
- Marshall, G., 1994. A comparative study of re-attenders and non-re-attenders for second triennial National Breast Screening Programme appointments. *J Public Health Med* 16, 79–86.
- Maxwell, C.J., Bancej, C.M., Snider, J., Feb 6 2001. Predictors of mammography use among Canadian women aged 50–69: findings from the 1996/97 National Population Health Survey. *Can Med Assoc J* 164 (3), 329–334.
- Michaelson, J., Satija, S., Moore, R., et al., 2002. The pattern of breast cancer screening utilization and its consequences. *Cancer* 94, 37–43.
- Peipins, L., Shapiro, J., Bobo, J., Berkowitz, Z., 2006. Impact of women's experiences during mammography on adherence to rescreening. *Cancer Cause Control* 17, 439–447.
- Perry, N., Broeders, M., de Wolf, C., Tornberg, S., Holland, R., von Karsa, L., 2008. European guidelines for quality assurance in breast cancer screening and diagnosis. Fourth edition – summary document. *Ann Oncol* 19 (61), 4–22.
- Sheppard, V., Wang, J., Yi, B., et al., 2008. Are health-care relationships important for mammography adherence in Latinas? *J Gen Intern Med* 23 (12), 2024–2030.
- Somkin, C., McPhee, S., Nguyen, T., et al., 2004. The effect of access and satisfaction on regular mammogram and Papanicolaou test screening in a multiethnic population. *Med Care* 42, 914–926.
- Tabar, L., Vitak, B., Chen, T.H., et al., 2011. Swedish two-county trial: impact of mammographic screening on breast cancer mortality during 3 decades. *Radiology* 260, 658–663.
- Tang, T., Patterson, S., Roubidoux, M., Duan, L., 2009. Women's mammography experience and its impact on screening adherence. *Psycho-Oncology* 18, 727–734.